CONDITIONING CATTLE TO CONSUME SALT CEDAR *TAMARIX* SP.

A Thesis

Presented to the

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Angelo State University

In Fulfillment of the

Requirements for the Degree

MASTER OF SCIENCE

by

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Major: Animal Science

CONDITIONING CATTLE TO CONSUME SALT CEDAR *TAMARIX* SP.

by

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ABSTRACT

Salt cedar (*Tamarix sp.* L), is found across Texas, primarily near riparian areas. Introduced in the 1800's as an ornamental plant, salt cedar escaped domestic gardens between 1900 and 1960, invading native rangelands. Control options for salt cedar are available, but effective control can be difficult and cost-prohibitive. Sheep and goats will readily consume salt cedar after exposure at weaning, although not a viable option in many areas due to predation or lack of appropriate fencing. Study objectives were to determine if cattle would consume salt cedar at a similar level (animal unit basis) as sheep and goats, and to determine if preconditioning improved acceptance of salt cedar by cattle. Angus-cross heifers, Rambouillet lambs, and Boer-cross kids were placed in individual pens. All animals readily increased intake of salt cedar through exposure and readily consumed the plant. Other data regarding intake of the plant by different species will be discussed.

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INTRODUCTION

Salt cedar (*Tamarix sp.* L), is found across Texas, primarily near riparian areas. Introduced in the 1800's as an ornamental plant, salt cedar escaped domestic gardens between 1900 and 1960, invading native rangelands. Early flood events are suspected to have aided in the spread of salt cedar seeds along riverbanks and floodplains (Birken and Cooper 2006). It is estimated that salt cedar covers nearly 650,000 ha in North America alone (Zavaleta 2000).

One common struggle that many ranchers face is controlling invasive brush species. There are several methods of brush management including mechanical, chemical, biological, and fire (Hernandez and Guthrie 2012). Mechanical means can include: dozing, chaining, excavating, and hand-cutting. Chemical removal involves the use of herbicides applied aerially or on an individual plant basis to cut stumps or as a basal or foliar spray. Biological methods can include introduction of insects that target specific brush species like prickly pear moths (Biosecurity Queensland 2016), Juniper beetles (Hayes et al. 2007), or grazing herbivores.

Many removal methods have been applied to salt cedar with varied results. Mechanical control and prescribed fire can be effective in removing aboveground growth, but it results in low mortality of the treated plants (Wiedemann and Cross 1979). The largest limiting factor in mechanical removal of salt cedar is its proximity to water. Soft soil and rough terrain can make it difficult to get machinery to the needed areas. Herbicide treatment faces limitations due to the proximity of *Tamarix* to waterways. This reduces the list of available herbicides for use. Imazapyr alone or mixed with glyphosate can result in mortality rates around 90% or higher. However, successful control is highly dependent upon timing, maturity, and chemical mixture rates (Duncan and McDaniel 1998). In addition, this method is labor-intensive and cost-prohibitive. Aerial spraying with Arsenal and Glyphosate results in mortality of Tamarix, but costs often exceed $150/ha.

Both sheep and goats will readily consume salt cedar (Munoz et al. 2017; Borroum et al. 2018). Salt cedar does not appear to cause aversive post-ingestive feedback and is relatively nutritious (Knight et al. 2018). Unfortunately, sheep and goats are not a viable option in many areas because of predation issues or lack of appropriate fencing. Thus, the purpose of this study was to determine if cattle will consume salt cedar at the same rate as sheep and goats.

OBJECTIVES

The objectives of this study were to determine if cattle would consume salt cedar at a similar level (animal unit basis) as sheep and goats, and to determine if preconditioning improved acceptance of salt cedar by cattle.

LITERATURE REVIEW

Sheep and goats have been used as a means of biological brush control in some situations (Frost and Launchbaugh, 2003). However, they are declining in popularity as an agricultural commodity. They require additional time to manage, as well as pose additional predation and fencing issues. Census data from the National Agricultural Statistics Service shows that nationwide inventory of sheep and lamb production was reduced by 37% since 1997 (Nass.usda.gov 2017). Goat production data was not available from the National Agricultural Statistics Service. Comparatively, cattle inventory has fluctuated some in the same timeframe, although it has recovered to a level similar to that in 1997 (Nass.usda.gov 2017). Historically, ranchers have not used cattle as a means of brush control because cattle diets are not comprised of brush type plant species like those of sheep and goats. However, it would certainly be helpful if cattle could learn to consume troublesome plants like salt cedar.

Sheep and goats, once conditioned, are viable control methods for many types of brush, including redberry (*Juniperus pinchotti* Sudw.) and ashe (*Juniperus asheii* Buchholz) juniper (Anderson et al. 2013; Dietz et al. 2010). Feeding juniper at weaning to both sheep and goats for 14 days results in acceptance of the plant as forage (Bisson et al. 2001; Dunson et al. 2007). Once released on pasture, juniper makes up 30% of the diet of goats throughout the year (Dietz et al. 2010). If protein is supplemented, juniper consumption is further enhanced (George et al. 2010).

Many producers no longer stock sheep or goats due to predator issues. Producers have reported losing 10-20 percent or more of their flocks annually to predators like coyotes, bobcats, and feral hogs (Marks 2017). Sheep and goat ranching also includes additional costs not seen in cattle ranching, such as shearing, internal parasite control, and the extra cost of building and maintaining net fencing. Previous literature shows that sheep and goats can be effectively conditioned to consume salt cedar (Muñoz et al. 2017; Borroum et al. 2018). Unfortunately, there is no information available on the willingness of cattle to consume the plant and if conditioning improves acceptance of the plant. This study compared intake of salt cedar among cattle, sheep, and goats and determined if conditioning at

weaning improved acceptance of the plant.

METHODS

Freshly weaned Angus x Hereford cross-bred calves, Rambouillet lambs, and Boer x Spanish cross kid goats were placed in individual pens and offered salt cedar daily. All individuals used in this study were naïve to salt cedar. Twenty head of each species were placed in individual pens at the Angelo State Management Instruction and Research Center (MIR Center) (Lat: 31.38, Long: 100.5). Recently weaned Angus x Hereford cross heifers weighing approximately 350 kg were used. Rambouillet lambs weighing approximately 45 kg and Boer cross kids weighing approximately 35 kg were also utilized. Intake on an individual animal basis was monitored daily by weighing all feed offered and then weighing refusals after 1 hour of feeding salt cedar. Salt cedar was harvested by hand-stripping leaves from trees growing on the ASU MIR Center along the receding shoreline of O.C. Fisher Reservoir. These samples were kept in a cooler (4^{o} C) to maintain freshness and quality.

All animals were weighed and randomly assigned to two groups, a treatment and a control. The control group received a basal ration (Table 1) fed at 2.5 % BW to meet maintenance requirements while the treatment group received the basal ration at the same level with the addition of being offered salt cedar daily for 14 days of conditioning. Thereafter, all individuals were fed salt cedar for seven days to determine if conditioning improved intake of the plant.

Animals were offered salt cedar for one hour each morning from 0800 to 0900, after which samples were removed from troughs and weighed. After removing salt cedar, animals were fed their individual allotment of daily mixed ration.

Both treatment groups were supplied with *ad libitum* water and the basal ration to meet daily nutrient requirements (National Research Council 2007; National Academies of Sciences, Engineering, and Medicine 2016). The basal ration, hereafter referred to as TMR, is a total mixed ration comprised of the ingredients detailed below (Table 1). Both treatment groups were fed only TMR for 7 days prior to feeding salt cedar to allow them to adapt to the environment and the basal ration before any further testing.

Table 1. Ingredients and nutrient content of total mixed ration.

Ingredients/Nutrients	As fed (%)
Alfalfa Pellets	10.0
Cotton Seed Meal	12.5
Cottonseed hulls	31.5
Cane molasses	3.5
Premix	2.5
Corn	40.0
DE	2.6 Mcal/kg
TDN	59.0
Crude Protein	14.5
Crude Fiber	14.2

Following the seven day adjustment period, the treatment groups received an equivalent of 5% of their diet in salt cedar. This salt cedar was available to them for one hour. Thereafter, all refusals were weighed. After 7 days of feeding salt cedar, the amount offered was increased to 10%. Over these given weeks, the control group did not receive any salt cedar and both treatment groups continued to receive 2.5% of their body weight in TMR. During the final week, both groups of animals were offered the equivalent of 10% of their diet in salt cedar daily for 1 hour with intake measured daily.

Body weight was measured at the beginning and at the end of the study for all groups. All methods were approved by the Angelo State University Institutional Animal Care and Use Committee prior to beginning the study, protocol number 2019-105.

STATISTICAL ANALYSIS

Data was analyzed using repeated measure analysis of variance. Species of livestock served as the main factor with conditioning serving as a subplot. Individual animals nested within treatments served as replications and day of collection as the repeated measure. Means were separated using Tukey's Protected LSD when $P \leq 0.05$. Data was analyzed using the statistical package JMP (SAS Institute 2007).

RESULTS

All three species of livestock readily consumed salt cedar (Fig. 1). However, on a BW basis, goats consumed more salt cedar than sheep or cattle. Sheep and cattle consumed a similar amount of salt cedar. All species were initially reluctant to consume salt cedar (Fig. 2). However, intake increased daily through exposure and as the amount of salt cedar was increased from 5% to 10% on day 8 and 15, respectively. Intake of salt cedar by cattle and sheep fluctuated daily while trending upward. Conversely, intake of salt cedar by goats increased daily until day 15. Thereafter, goats typically consumed all of the salt cedar offered daily (Fig 2).

The two week adaptation period did not improve intake of salt cedar by cattle, sheep or goats (Figs. 3, 4, 5). Regardless of conditioning, all species consumed salt cedar. In addition, salt cedar intake fluctuated daily especially for cattle but tended to remain relatively constant for sheep and goats during the last seven days of the study.

All animals gained weight from the beginning to the end of the study (Table 2.). Feeding salt cedar did not affect weight gain (Treatment and Treatment by Time interaction were similar, $P > 0.05$).

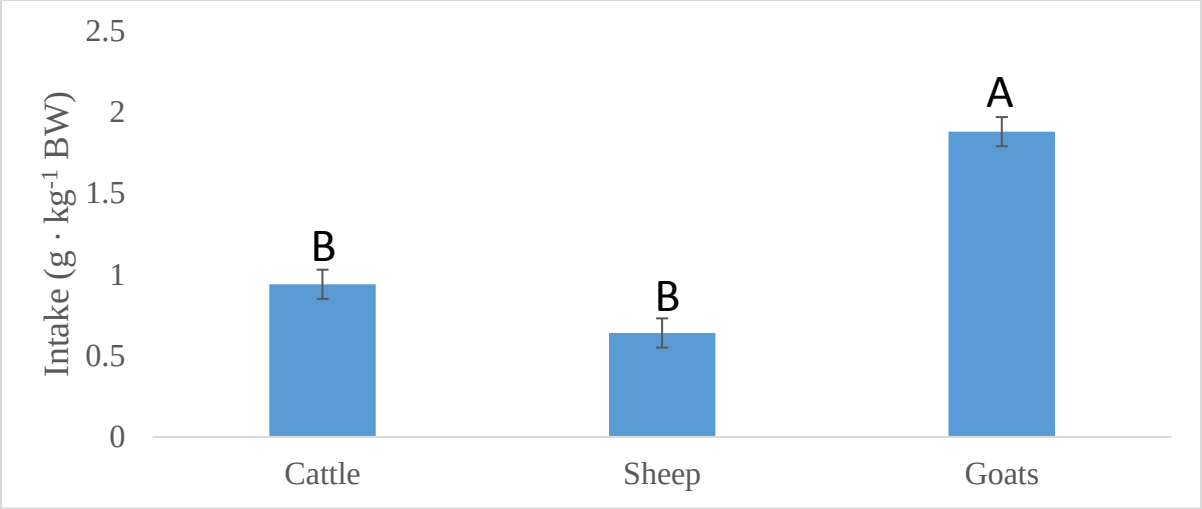

Figure 1. Intake ($g \cdot kg^{-1}$) of Salt cedar by cattle, sheep and goats fed the plant for 21 days in individual pens. $^{A-B}$Those columns sharing a letter of significance do not differ ($P < 0.05$).

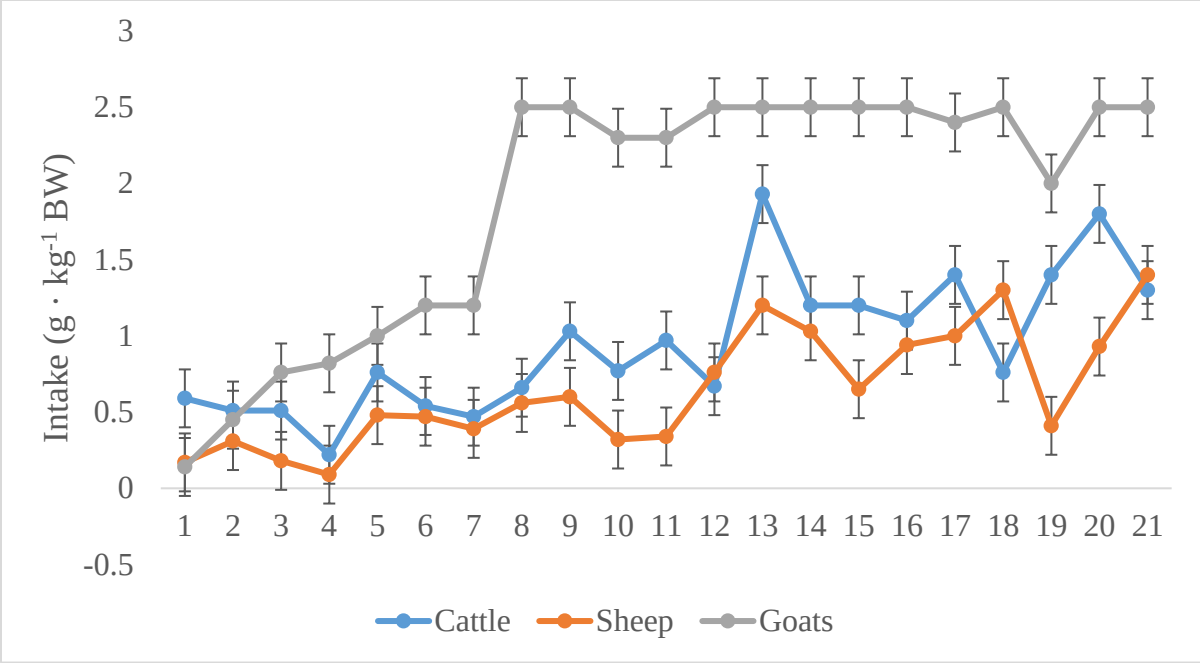

Figure 2. Intake ($g \cdot kg^{-1}$) of salt cedar for cattle, sheep, and goats fed the plant for 21 days in individual pens. For the first seven days, all individuals were fed a diet consisting of 10% salt cedar. For the last 14 days, animals received a diet of 20% salt cedar.

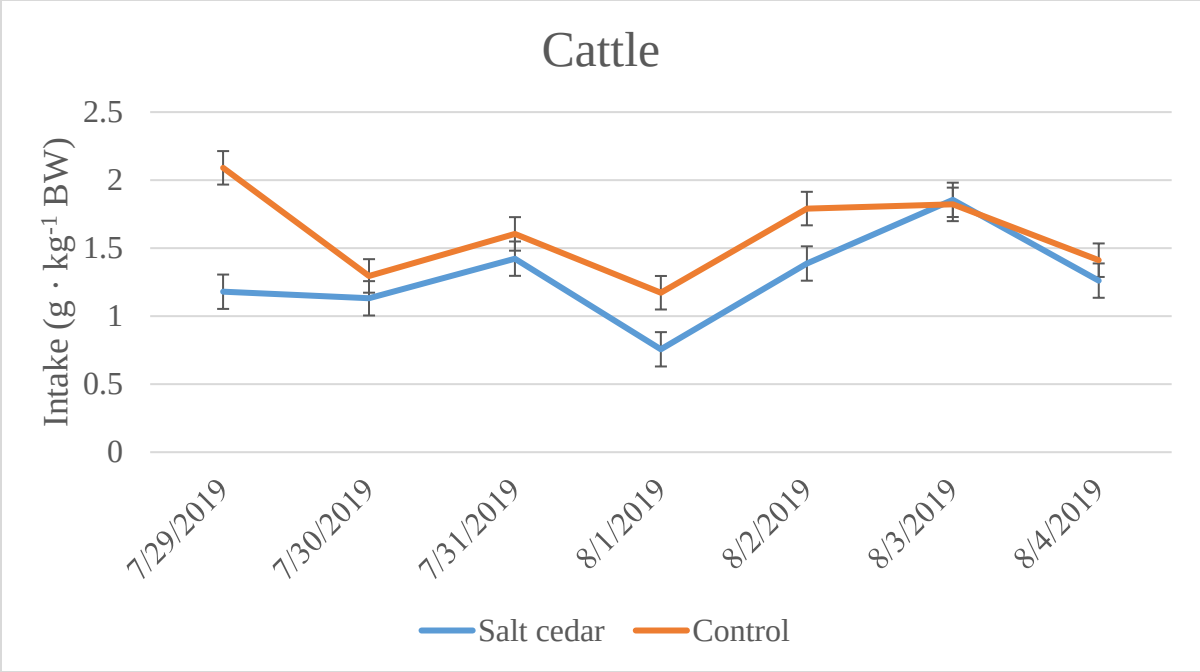

Figure 3. Cattle intake ($g \cdot kg^{-1}$) of salt cedar following feeding salt cedar for 21 days. Those individuals in the control group were naïve to salt cedar prior to being offered the plant for the last seven days of the study.

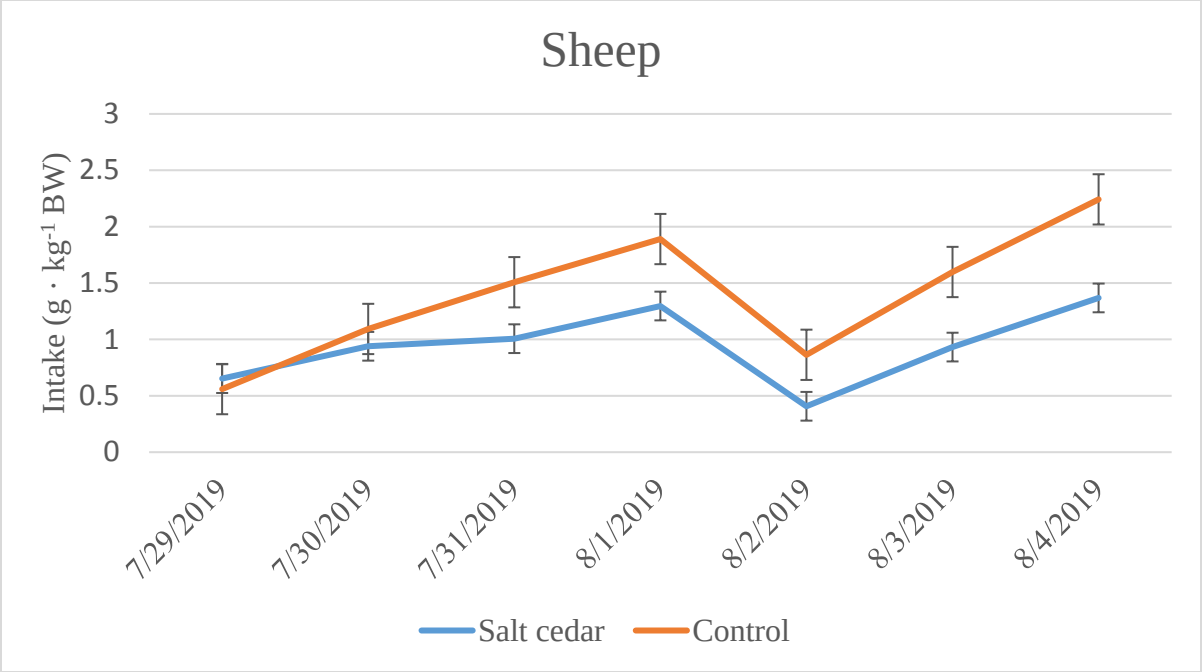

Figure 4. Sheep intake ($g \cdot kg^{-1}$) of salt cedar following feeding salt cedar for 21 days. Those individuals in the control group were naïve to salt cedar prior to being offered the plant for the last seven days of the study.

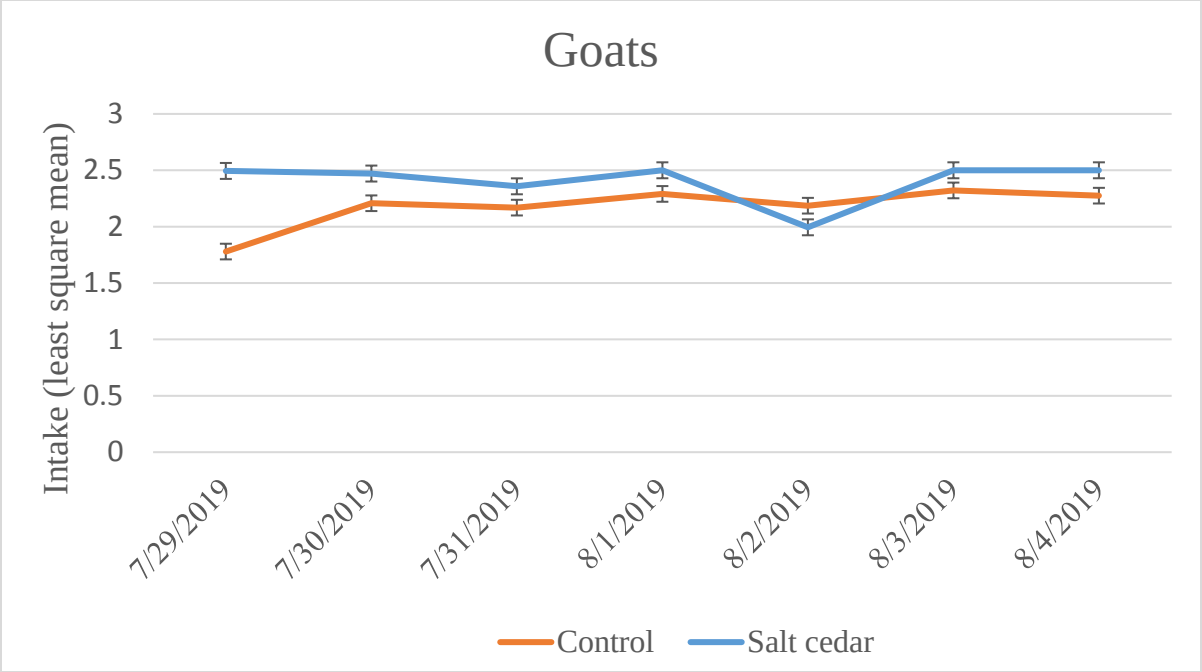

Figure 5. Goat intake ($g \cdot kg^{-1}$) of salt cedar following feeding salt cedar for 21 days. Those individuals in the control group were naïve to salt cedar prior to being offered the plant for the last seven days of the study.

Table 2. Initial and Ending weights (kg) for cattle, sheep, and goats. Animals were weighed prior to initiation of the study and immediately after the study was concluded.

Species/Treatment	Weight (kg)		SEM
	Initial	Ending	
Cattle			
Salt cedar	304.4	326.2	8.8
Control	305.0	324.5	8.8
Sheep			
Salt cedar	75.9	85.3	4.1
Control	77.0	94.6	4.1
Goats			
Salt cedar	41.2	50.2	2.5
Control	41.4	48.8	2.5

DISCUSSION

On day 1 of the experiment, all animals regardless of species, were hesitant to consume salt cedar, however as the experiment progressed intake increased. Goat intake increased quickly, similar to that seen in other studies (Munoz et al. 2017). Ruminants, typically, are slow to consume novel foods. While initially hesitant, intake will increase as long as the food contains essential nutrients or does not result in aversive post-ingestive feedback (Provenza 1995; Provenza et al. 1994). A positive response between salt cedar intake and animal performance is likely due to nutritional quality of the plant itself. Salt cedar is nutritious averaging a reported 16-19% Crude Protein and 67.5-69.4% TDN (Knight et al. 2018). In addition, consumption of salt cedar apparently does not result in aversive post-ingestive feedback and the formation of a conditioned food aversion in goats (Munoz et al. 2017) or sheep (Borroum et al. 2018). Based on the results of this study, salt cedar does not appear to result in aversive post-ingestive feedback in cattle as well. In addition, all animals gained weight during the current study regardless of treatment or species further suggesting that salt cedar is a nutritious forage for cattle, sheep, and goats.

While all three species readily consumed salt cedar, intake by cattle and sheep fluctuated daily. Conversely, goats consumed all salt cedar offered at the end of the study. In addition, it appeared that their intake would continue to increase as the amount of salt cedar offered to them increased. Both cattle and sheep are considered bulk/roughage feeders while goats are considered intermediate feeders, able to consume a bulk/roughage or concentrate diet (Hoffman 1989). Differences in ability to consume and digest concentrate diets, like salt cedar are typically attributed to morphological characteristics (mouth size), foraging skills (prehensile skills), and physiological characteristics (rumen size and function). Given the morphological and physiological of goats, this species may be expected to consume more salt cedar on rangelands.

Water intake was not recorded for this study. Previous studies reported no differences in water intake when goats were consuming salt cedar (Knight et al. 2018). In addition, when goats were

foraging on stands of salt cedar on rangelands, water intake was very low apparently because of the high water content in the plant (Rogers 2013).

Weaning appears to be a critical time for introducing novel food items into the ruminant diet, including some that may contain compounds that cause aversive post-ingestive feedback. Previous efforts have illustrated that both goats and sheep will increase intake of redberry juniper when fed the plant at weaning (Bisson et al. 2001; Anderson et al. 2013; George et al. 2010). In addition, experiences early in life may affect morphological, physical, and neurological responses to plants that can cause gastrointestinal distress; Distel and Provenza (1991) fed goats at 6 weeks of age blackbrush (*Coleogyne ramosissima* Torr.) daily. Blackbrush contains condensed tannins that are toxic to ruminants. Goats introduced to blackbrush early in life consumed 95% more blackbrush than naïve goats, were more efficient at digesting blackbrush, and excreted more uronic acid apparently because of an increased ability to detoxify the tannins in blackbrush.

Using experiences early in life as a diet training tool can offer managers new opportunities when battling non-preferred plants, creating a group of foragers specific to management goals (Provenza et al. 1988). In circumstances where landowners cannot graze sheep or goats due to predators or lack of appropriate fencing, cattle offer a useful option for herbivore grazing of salt cedar. In scenarios where any of the three mentioned species are feasible options, goats are the highest salt cedar consuming species. They consumed all salt cedar offered and adapted to the novel food at a faster rate than sheep or cattle. Sheep, cattle, and goats are all feasible options for adaptation to a salt cedar diet.

MANAGEMENT IMPLICATIONS

All species of livestock readily consumed salt cedar. As a result of these findings, all species could be considered biological control options. Subject to specific circumstances and needs, cattle could be the best biological control option for some landowners, especially when it is not feasible to stock sheep or goats. While this study focused on the ability of cattle to consume salt cedar when offered to them in a pen setting, further studies are needed to determine the feasibility of cattle consuming the plant in a rangeland setting.

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APPENDIX

ANGELO STATE UNIVERSITY

College of Graduate Studies & Research

Institutional Animal Care & Use Committee

July 3, 2019

Cody Scott, Professor

Agriculture

Angelo State University

ASU Station #10888

San Angelo, TX 76909

Your proposed project titled, "Conditioning cattle to consume salt ceduar (tamarix sp.)" was reviewed by Angelo State University's Institutional Animal Care and Use Committee (IACUC) in accordance with the regulations set forth in the Animal Welfare Act and P.L. 99-158.

This protocol was approved for three years, effective July 3, 2019 and it expires three years from this date; however, an annual review and progress report form (www.angelo.edu/content/files/22583-iacucannual-review-progressreport) for this project is due on August 15 of each year. If the study will continue beyond three years, you must submit a request for continuation before the current protocol expires.

The protocol number for your approved project is 2019-105. Please include this number in the subject line of in all future communications with the IACUC regarding the protocol.

Sincerely,

Chase Runyan, Ph.D.

Co-Chair, Institutional Animal Care and Use Committee

VITA

Shelby Crockett Parker, born Shelby Crockett of Clifton. Texas, was raised on a small horse and cattle ranch by her parents Colby and Vicki Crockett. It was here where she developed a passion for land and livestock management. After a 10 year career in 4-H she moved to San Angelo in 2014 to pursue a college education at Angelo State University. Completing two separate undergraduate degrees she tapped into multiple passions finishing a Bachelor of Business Administration degree in Finance with a real estate option and a Bachelor of Science majoring in Animal Science with a minor in Range and Wildlife Management. Crockett graduated summa cum laude in 2018. Upon completion of her undergraduate degree programs, she pursued a Master of Science degree in Animal Science specializing in Range and Wildlife Management while also completing a certification program in Rangeland Management and Beef Industry Leadership. Shelby married Lance Parker of San Angelo, Texas in December of 2019, prior to her graduation from Angelo State in May of 2020. Diploma in hand, Parker sets her sights on a career serving landowners in preserving proper land management practices for many more generations of sustainable agriculture.